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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ETL-R-076	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A New and Extensive Thermal Contrast Data Base		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. E. Rice, OptiMetrics, Inc., and A. E. Krusinger, USAETL		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Engineer Topographic Laboratories Fort Belvoir, VA 22060-5546		12. REPORT DATE 14 Feb 85
		13. NUMBER OF PAGES Five
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) n/a		15. SECURITY CLASS (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release. Distribution Unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES → 212 0.03		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) thermal contrast; radiometric measurements; targets; meteorological measurements backgrounds. C		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The performance of thermal sensors against ground targets depends upon the thermal contrast between the particular targets and the backgrounds. This thermal contrast is highly variable and it is background and target specific. It also depends upon the time of day and the weather conditions. In support of Tactical Decision Aid development, a data base which contains thermal contrast as well as weather variables is being converted to computer-compatible tape. This data base consists of radiometric measurements of targets, background, and incoming long and short wavelength radiation, as well as on-site meteorological		

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A NEW AND EXTENSIVE THERMAL CONTRAST DATA BASE

11 February 1985

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ABSTRACT

The performance of thermal sensors against ground targets depends upon the thermal contrast between the particular targets and the backgrounds. This thermal contrast is highly variable and it is background and target specific. It also depends upon the time of day and the weather conditions. In support of Tactical Decision Aid development, a data base which contains thermal contrast as well as weather variables is being converted to computer-compatible tape.

This data base consists of radiometric measurements of targets, backgrounds, and incoming long and short wavelength radiation, as well as on-site meteorological measurements made almost continuously over more than a two year period by the US Army Engineer Topographic Laboratories at Fort Belvoir. Standard weather measurements made at the nearby Davison Army Airfield are also combined with the on-site measurements. This paper describes this new data base which can be used to develop or validate thermal contrast models, develop rules of thumb for thermal contrast prediction, validate Tactical Decision Aids, or develop statistical distributions of thermal contrast as a function of the time of day or the weather conditions.

1.0 INTRODUCTION

The performance of weapon systems which depend upon the thermal contrast between the target and various backgrounds is also affected by the weather since the weather has a great influence upon this target-background thermal contrast. The behavior of this contrast in the real world is very complex. It is dependent upon the specific target as well as the specific background. It also depends upon the current weather conditions of solar load, incoming IR radiation, humidity, precipitation, air temperature, and wind speed. It is time-of-day dependent and also varies with the season and soil moisture conditions. Because of the great variety of conditions which influence thermal contrast, there is a need for a data base which encompasses the many variables which describe the various weather conditions in which these infrared systems are expected to operate.

The Air Force Geophysics Laboratory has sponsored a survey of data bases which could be used to test the Thermal Contrast Models which are part of the Tactical Decisions Aids for the US Air Force [1]. These Tactical Decision Aids will permit the field commander to predict the performance of his weapon suites in the diversity of weather conditions which may be encountered in the field. Although a large quantity of data has been taken for the evaluation of IR systems, for the evaluation of the IR signatures of a number of targets, and for the development of scene statistics, these data bases are limited in their weather characterization, the number of diurnal cycles covered, the seasonal coverage, and the variety of weather

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conditions encountered during the measurements. These data bases also fail to capture the dynamic nature of thermal contrast. They present a static picture of the thermal contrast in a scene at a particular moment of time instead of a moving picture of the changes in thermal contrast under changing weather and time of day conditions. As a result of the deficiencies in these other data bases, the data obtained by the Army Engineer Topographic Laboratories are of great research value in the study of thermal contrast. These data are being transferred to computer-compatible tape.

It is expected that this data base will be extremely useful for (1) the development of thermal contrast models, (2) the validation of thermal contrast models, (3) the development of rules of thumb for expected thermal contrast, and (4) the development of statistical distributions of thermal contrast for selected weather categories, times of day, and seasons.

2.0 ARMY ENGINEER TOPOGRAPHIC LABORATORIES THERMAL CONTRAST DATA BASE

The Army Engineer Topographic Laboratories Thermal Contrast Data Base consists of almost continuous measurements with a Barnes PRT-5 Radiometer of brightness temperatures of selected background plots and targets, along with supporting meteorological measurements. The site is located at Fort Belvoir, Virginia. A schematic outline of the site is shown in Figure 1. The background plots consist of (1) cut grass, (2) bare soil, (3) uncut grass, (4) cut grass from another aspect angle, and (5) aggregate gravel. The site also includes a target station. Targets which have been located at this station are a large aerial tower truck (2) and an M114 armored reconnaissance vehicle. Each background plot and the target station is scanned at a fixed interval with the same radiometer. In addition, another radiometer measures the brightness temperature of a Douglas fir. Figure 2 is a photograph of the test site with the M114 in place. The PRT-5 radiometer is located near the top of the tower shown in the photograph.

Meteorological measurements are also made at the same site. These are listed in Table 1. These include air temperature at a variety of tower heights, dew point temperature, barometric pressure, wind speed, wind direction, and amount of precipitation.

Other radiometric measurements include incoming short-wave radiation, incoming long-wave radiation, and net short-wave radiation for the various plots. Measurements of soil temperature, soil moisture, and soil heat flux are also made at various depths. The radiometric measurements and soil measurements are listed in Table 2.

During 1979 and 1980, the measurement program concentrated on radiometric temperatures of the four backgrounds, without a vehicle (3). In 1981, radiometric temperature measurements were made of evergreen trees and a cut grass background.



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The measurement program in essentially the present configuration began in June 1982. From June 1982 to May 1984 approximately 26,600 measurement sets have been taken; of these approximately 22,200 measurement sets were taken from June 1983 to May 1984. During this latter year, on the average, one measurement set was made every 24 minutes. The measurement frequency rate has varied from approximately once every eight minutes to once every 40 minutes. Data has been taken 24 hours a day throughout all seasons. Measurements have continued since May 1984.

After they are taken, the measurements are stored on a Hewlett-Packard 9895A formatted eight-inch floppy disk. In order to make them more accessible, data from June 1982 to May 1984 are being transferred to computer-compatible tape. The format for the computer-compatible tape is that developed by the Targeting Systems Characterization Facility (TSCF) [4].

Weather data from the nearby Davison Army Airfield at Fort Belvoir are also being added to the data set. This will provide the user with standard weather observations made by Air Force observers. It also supplements the ETL measurements by providing visibility and cloud cover information. The hourly weather measurements made at Davison Army Airfield are written in the TSCF format; the ETL weather measurements, radiometric measurements, and soil measurements are added as an additional word group in the TSCF format.

The conversion of this data base to a computer-compatible tape format has been sponsored by the Air Force Systems Command and the Air Force Geophysics Laboratory, and supported by the Army Engineer Topographic Laboratories.

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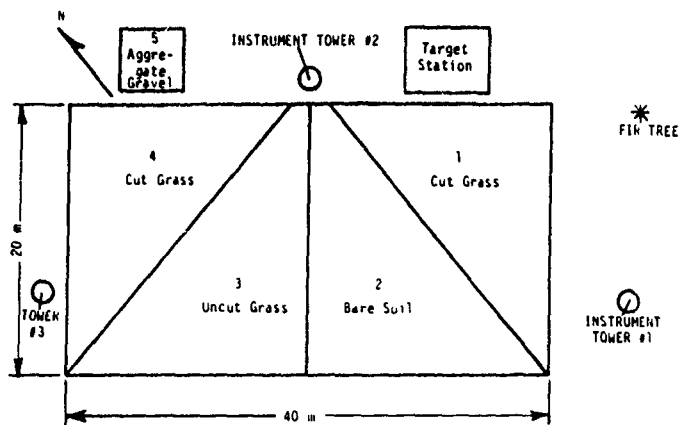


FIGURE 1 SCHEMATIC OF TEST SITE LAYOUT

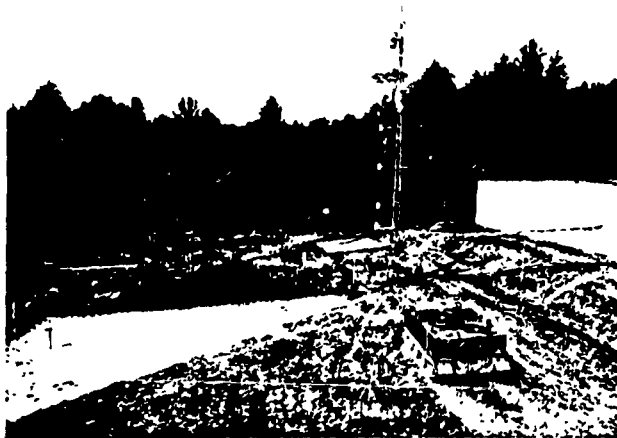


FIGURE 2. PHOTOGRAPH OF TEST SITE, LOOKING NORTHWEST

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TABLE 1. METEOROLOGICAL MEASUREMENTS RECORDED AT ETL

TYPE OF MEASUREMENT	LOCATION	INSTRUMENT
Air Temperature (°C)	Tower 1 10,50,120,200,300 cm height	Thermocouples in Weathermeasure Model IS-6, Aspirated Radiation Shield
	Tower 2 10,50,120,200,300,400,600 800,1000,1200 cm height	Thermocouples in Weathermeasure Model IS-6, Aspirated Radiation Shield
Dew Point Temperature (°C)	Tower 2, 120 cm height	General Eastern Model 1100 MPS and YSI 9400-STD Dew Cell
Barometric Pressure (mb)	Building, 120 cm height	Meteorological Research, Inc. (MRI) Model 751
Wind Speed (m/s)	Tower 1 and 3, 120 cm height Tower 2, 15 m height	Gill 3-Cup Anemometer Model 12102
Wind Direction	Tower 2, 15 m height	MRI Model 10220-2
Cumulative Precipitation Amount (mm)	Edge of plot 3	MRI Model J04

TABLE 2. RADIOMETRIC AND SOIL MEASUREMENTS

TYPE OF MEASUREMENT	LOCATION	INSTRUMENT
Brightness Temperature (°C)	Plots 1,2,3,4,5 and Target Station	Barnes PRT-5
Brightness Temperature (°C)	Douglas Fir	Barnes PRT-5
Incoming Short-Wave Radiation (.28 to 2.8 μ m)	Building Roof	Eppley Precision Pyranometer Model PSP
Incoming Long-Wave Radiation (3 to 50 μ m)	Building Roof	Eppley Precision Infrared Radiometer Model PIR
Soil Temperature (°C)	Plots 1,2,3,4 1,4,10,20,40,80,160 cm depths	Thermocouples
Soil Moisture Resistance (Ω)	Plots 1,2,3,4 4 and 12 cm depths	Coleman Soil Moisture Cell Soil Test Mdl. MC310A
Soil Heat Flux (W/m ²)	Plots 1 and 2 4 and 12 cm depths	Thermometrics Model H11-18-1-SHF